Palmerton OU-4
Deep Aquifer
Evaluation

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Adrian**Brown**

Innovative Environmental Solutions

130 West Fourth Avenue
Denver, Colorado 80223
303.698-9080 Fax 303.698-9241
www.abch2o.com

1. INTRODUCTION 1

2. GEOHYDROLOGY 1

3. HISTORY 1

4. DEEP AQUIFER WELL QUALITY 1

5. WATER SUPPLY QUALITY 2

6. EVALUATION 2

7. PROJECT IMPACT ON DEEP GROUNDWATER 3

8. DATA GAPS FOR EVALUATION OF DEEP AQUIFER CONNECTION 4

List of **Tables**

Table 1 - Water Quality - Circa 1997 7

List of **Figures**

Figure 1 - Geological Section Looking East 8
Figure 2 - Well Locations - Palmerton East Plant 9
Figure 3 - Deep Wells - Zinc Concentration History 10
Figure 4 - Deep Well Sulfate History 11
Figure 5 - Palmerton Water - Zinc Concentration History 12
Figure 6 - Monitor Wells - Zinc Concentration History 13
Figure 7 - Aquashicola Creek - Zinc Concentration History 14
Figure 8 - Deep Wells - PCE History 15

1. INTRODUCTION

The Remedial Investigation of Operable Unit 4 ("OU-4") of the Palmerton Zinc Pile Superfund Site ("Site") has been in progress since 2000. A Draft Remedial Investigation Report - Palmerton Zinc Pile - Operable Unit 4, Palmerton, Carbon County, Pennsylvania, June 2002, was prepared for USEPA Region III by Tetra Tech/Black & Veach (TT/BV). CBS Operations Inc. ("CBS"), formerly Viacom International Inc. ("Viacom") has requested Potentially Responsible Party lead to complete the Remedial Investigation ("RI") and Feasibility Study ("FS").

Groundwater has been extracted from site wells for many years, and the resulting water treated by chlorination, filtration, and supplied as drinking water to the Borough of Palmerton. This report presents the results of an evaluation of the impact of metals on the deep groundwater at the Site.

2. GEOHYDROLOGY

The geohydrology in the vicinity of the Site comprises a shallow alluvial aquifer which fills the valley of Aquashicola Creek to a depth averaging 70 feet, underlain by interbedded siltstones, sandstones, and shales, dipping steeply to the south (Figure 1).

3. HISTORY

Water supply has been provided to Palmerton from the following sources (see Figure 2 for locations):

1. Wells 9, 9A, 9B, 9C, and 9D (the "Curb Wells"). The Curb Wells provided water for the zinc processing facility, and the Borough of Palmerton. These wells were completed sequentially in the shallow alluvium beside Aquashicola Creek, and are 15 to 20 feet deep. They were phased out between 1966 and 1982 as concentrations of metals in the delivered water increased.
2. Wells 4, 6, and 7. This group of three wells was completed at approximately 300 feet depth in the bedrock beside Aquashicola Creek at the west end of the East Plant. They have supplied plant water and borough water since 1927.
3. Well "A". This well, which is 685 feet deep, is located in the center of the East Plant. It has provided water to the borough since 1983.

4. DEEP AQUIFER WELL QUALITY

The quality of the water in the deep aquifer wells has been monitored since their inception. The concentration of zinc in the deep wells is presented in Figure 3 below. The concentration of zinc has risen slowly over the period of record in Well 7 and Well A, which are separated by some 1,000 feet, and are completed at 300 and 685 feet depth, respectively. Concentrations of zinc in all wells have been decreasing in recent years.

The concentration of sulfate in the wells is useful as an indication of the genesis of the water. The water has been occasionally analyzed for sulfate (and other major ions) in the wells in recent years. The sulfate

information is presented in Figure 4. The concentration of sulfate in the deep wells has increased from a few milligrams per liter in the 1930s to a peak in Well 7 and Well A of approximately 250 mg/L by 2000. The concentration of sulfate in Well 4 and Well 6 is lower, in the range of 20 to 120 mg/L.

Organic chemicals have been monitored in the PWC supply wells since 1986. The only significant detection of organic chemicals in the deep aquifer wells has been perchlorethylene (PCE), as shown in Figure 8. The small concentration of PCE detected appears to be derived from Well 7, with a single small detection in Well 6.

5. WATER SUPPLY QUALITY

The quality of the water supply for the Borough of Palmerton is governed by the water supplied from the deep wells[1]. The quality of the water delivered to the Borough has been monitored routinely at a number of locations in Palmerton. The results of this monitoring for zinc are presented in Figure 5.

This record is similar to the zinc concentration measured in the deep wells, with higher zinc in the early years of record representing some contribution to the borough water supply from the Curb Wells. The zinc concentration in the water supplied to Palmerton in recent years reflects and confirms the decrease in the zinc concentration in the deep wells.

Limited information on major ions is available for the distributed water; as such analyses are not generally required for supplied water. Data taken in the mid-1990s indicates that the sulfate concentration in the borough water was approximately 120 mg/L.

Organic chemicals were essentially absent from supplied water; a single detection of PCE (0.62 µg/L) occurred in one town reservoir in 1986.

6. EVALUATION

The concentration of zinc in the deep aquifer wells has been evaluated with respect to the potential sources of the metals and other dissolved constituents. This evaluation has been performed with respect to the trends of zinc and sulfate concentration in the deep aquifer, and potential source areas. In addition, total chemical information has been assembled from a range of potential sources, and is presented in Table 1 for the period around 1997 (the deep aquifer wells and most potential source locations were sampled for a relatively wide range of constituents in that time period).

There are a number of potential sources for zinc in the deep aquifer at the East Plant:

1. Shallow Aquifer. The shallow groundwater aquifer directly overlies the deep aquifer wells and contains dissolved zinc at a concentration of approximately 1 mg/L, largely derived from zinc smelting and cinder disposal operations. The zinc concentration history in the shallow aquifer at the east end of the East Plant is presented in Figure 6. The concentration of major ions in the shallow aquifer is moderate, as shown in Table 1. TDS is in the 300-350 mg/L range.

[1] A small percentage of the total water supplied to Palmerton by the Palmerton Water Company is obtained from surface water sources in Aquashicola Creek and Pohocopo Reservoir, upstream of the Palmerton zinc processing facility.

2. Aquashicola Creek. Aquashicola Creek flows along and slightly south of the subcrop of the geologic beds from which the deep wells draw their water, and so the creek could be a source of the water that is produced from the wells. Zinc concentrations observed in Aquashicola Creek have been declining from 2.7 mg/L in recent years, as shown on Figure 7. The concentration of major ions in the creek is low. TDS is approximately 132 mg/L.
3. Palmerton Alluvium. The subcrop of the units from which the deep wells draw their water is generally in the vicinity of the Borough of Palmerton. This water is not monitored, but is expected to contain relatively high concentrations of dissolved constituents, and may contain urban impacts including PCE (from dry cleaning facilities).

Based on the above source evaluation, it would appear that the deep aquifer wells draw water differentially from the available sources, depending on their location:

1. Well 4: This well is the most upgradient well at the toe of Blue Mountain, and has very pure water, with a TDS of 113 mg/L. The water for this well is generally un-impacted by anthropogenic sources, and must be sourced from precipitation on Blue Mountain.
2. Well 6: This well is intermediate between Well 4 and Well 7, and both in location and water quality. The quality of the water drawn from this well is similar to that of Aquashicola Creek and the shallow aquifer in the same vicinity, except that it generally contains very little zinc. The source of this water appears to be a mixture of local shallow aquifer water and Aquashicola Creek water.
3. Well 7: This well is the most northerly of the three western supply wells. The concentration of major ions in this well significantly exceeds all measured local sources, indicating that the principal source of this water is not the local East Plant shallow aquifer or Aquashicola Creek. The presence of PCE in this well (alone except for one slight detection in Well 6) suggests contribution of water from the developed area of Palmerton. The concentration of zinc and major ions is similar to shallow aquifer concentrations in the vicinity of Well A. These factors together indicate that this well receives groundwater from the east and the north, but not in significant measure from the Aquashicola or the overlying aquifer.
4. Well A. This well is the most easterly of the deep supply wells. The quality of water drawn from the well is generally consistent with the water in the overlying shallow aquifer, except that zinc concentrations are somewhat lower. This water appears to be predominantly sourced from the shallow aquifer in this location, with zinc and other metal attenuation by adsorption.

7. PROJECT IMPACT ON DEEP GROUNDWATER

Groundwater in the deep aquifer that provides the water supply for Palmerton appears to be sourced predominantly from the shallow aquifer, either directly above the intake screens of the wells (Well 4, Well 6, and Well A), or from more remote locations in the shallow aquifer (Well 7). The water is drawn down through overlying bedrock units to the screened interval of the wells. Secondary sources are Aquashicola Creek and the alluvium on the north side of Aquashicola Creek beneath Palmerton.

The concentration of potentially Site-related constituents (particularly zinc) in the water produced by wells in the deep bedrock aquifer(s) has been monitored for many years, both directly at the wells (Figure 3), and indirectly at a number of supply points in Palmerton (Figure 5). These data indicate that the concentrations of potentially Site-related constituents have never reached concentrations that are significant from a water supply perspective, and have stabilized or are declining in recent years. In particular, zinc has declined to less than 0.5 mg/L in supplied water from the Palmerton Water Company system, which is 10% of the (secondary) drinking water standard for this constituent.

Sulfate has also stabilized or declined in the water supply wells in recent years (Figure 4), and is now estimated to average approximately 87 mg/L in the supplied water to Palmerton (Table 1)[2]. This is approximately one third of the (secondary) drinking water standard for sulfate of 250 mg/L.

The stabilization and/or decline of the concentrations of potentially Site-related constituents in the deep aquifer wells and in the water supplied to the Borough of Palmerton is attributed in part to the effects of the remedial actions that have been taken in the vicinity of the East Plant, including revegetation of Blue Mountain, revegetation of the cinder bank, and collection and treatment of surface and shallow groundwater. These remedial actions have reduced availability and mobility of zinc and other materials in the catchment area of the deep aquifer.

The concentrations of potentially Site-related constituents in the deep aquifer wells and in the supplied water from the deep aquifer is limited by the concentration in the shallow aquifer, and in Aquashicola Creek, and will continue to be so in the future. These source concentrations are expected to either remain static or to continue to decline as the remedial actions associated with OU-4 are completed. Therefore, it is expected that concentration of zinc in the deep aquifer at the Site has peaked and will continue to decrease in the future.

8. DATA GAPS FOR EVALUATION OF DEEP AQUIFER CONNECTION

The information available relating to the deep aquifer provides guidance for completion of the investigation of the deep aquifer for the OU-4 RI. Specifically, the evaluation of the genesis of deep aquifer water is lacking two lines of evidence for this purpose:

1. Physical Flow System Information. No pumping test has been performed that quantifies the connection between the deep aquifer wells and the shallow groundwater or surface water system. Three evaluations performed in 1986 by W.E. Wright[3,4] do provide some information about aquifer connection:

[2] Sulfate is not measured routinely in the town water samples taken. This sulfate estimate is based on developing a mixture of the four constituent well waters to produce the observed TDS of the supplied water in the town, and then applying the same mixture to the (measured) sulfate in each of the supply wells.

[3] Groundwater Monitoring System Report, Project 8520. Report prepared for New Jersey Zinc East Plant, Palmerton, by W.E. Wright Associates, Middletown, PA, February 1987.

[4] Remedial Investigation Report. Report prepared for The New Jersey Zinc Company, Palmerton, Pennsylvania, by W.E. Wright Associates, Middletown, PA., November 20, 1987.

a. Pumping Test of MW-1. A pumping test of the alluvial groundwater system was performed at the west end of the East Plant by producing shallow aquifer well MW-1 at a rate of 15 gpm for 3 days. Monitor wells in the vicinity were recorded. The pumping produced a drawdown of approximately 3.5 feet in MW-1, but MW-1 and the monitor well showed a similar cyclic response to the pumping of the deep wells in the vicinity (PW-4, PW-6, and PW-7). These wells are completed at a depth of approximately 300 feet below ground surface, and when operating pumped at a combined rate of approximately 375 gpm. This test indicates that there is a connection between the shallow aquifer and the deep bedrock aquifer(s) at this location; the extent and hydraulics of the connection were not determined.

b. Pumping Test of RCRA-4. A pumping test of the groundwater system was performed at the center of the East Plant by pumping Well RCRA-4, completed in the shallow aquifer, at 45 gpm for 3 days. Monitor wells in the vicinity were recorded, including the Acid Plant Well (Pumping Well "A"), completed at a depth of 645 feet in the bedrock aquifer. No response to the pumping of RCRA-4 was measured in the Acid Plant Well. Further, no response was identified in any of the monitor wells in the shallow aquifer in the vicinity of the Acid Plant Well due to pumping of that well during portions of the test period. The Acid Plant Well had a pumping capacity at the time of 125 gpm, although the pumping activity during the test was not reported. This test indicates that there is no hydraulically measurable connection between the shallow aquifer and the deep bedrock in this location.

c. Pumping Test of MW-11. A pumping test of the shallow aquifer system at the east end of the East Plant area by producing MW-11 at a rate of 50 gpm for 3 days. Response to pumping was recorded in surrounding shallow aquifer wells. A drawdown of approximately 13 feet was recorded at MW-11, and a drawdown of 1.5-2.5 feet was recorded in nearby shallow completions in MW-11A and MW-11B. However, essentially no drawdown (0.1 feet) was measured in the deepest completion of MW-11B, at a depth of approximately 39 feet below ground surface. This result indicates that the shallow groundwater system is separated from the deep bedrock groundwater system in this location.

Accordingly, a test of the deep aquifer system connection to surface water is required at the west end of the East Plant to quantify the degree of connection of the deep bedrock aquifer(s) to surface water and shallow groundwater. This test should be performed by a long term perturbation to the deep aquifer pumping system, which can most readily be obtained by turning off Wells 4, 6, and 7 for several days, and monitoring the effects on water levels in deep and shallow wells in the area. This test will allow quantification of the degree of connection between the deep bedrock aquifer(s) and the shallow water sources, including the shallow groundwater system and Aquashicola Creek.

2. Chemical System Information. A large amount of information is available on the chemistry of the surface water and groundwater in the vicinity of the East Plant, as presented in this report. This information allows detailed historical evaluation of water quality in surface water, shallow groundwater, and deep groundwater, particularly with respect to metals.

   However, as is clear from the summary, there is no time-contemporaneous set of major ion and metal water chemistry, which is needed to better define the sources of water that supply the deep groundwater system. Further, there is no data available to clearly identify the genesis of water in the deep aquifer system, for example to allow tracer or fingerprint analysis of the water.

   Accordingly, collection of complete chemical and isotopic data for two periods (high flow and low flow) for surface water, shallow groundwater, and deep groundwater at the site is required for confirmation of the source(s) of water to the deep bedrock groundwater system.

The deep bedrock pumping test data and the detailed chemical data will allow quantification of the source(s) of water to the deep aquifer, and quantification of the potential risk, if any, of future impact to that groundwater from the Site.

Table 1 - Water Quality - Circa 1997

LOCATION	DEEP WELLS				TOWN [1995-1997]	AQUASHICOLA (2001)	EAST PLANT MONITOR WELLS				
	WELL_4 [1997]	WELL_6 [1997]	WELL_7 [1997]	WELL_A [1997]			MW-01 [1997]	MW-02 [1997]	MW-03 [1997]	MW-04 [1997]	MW-06 [1997]
pH-s.u.	6.6	6.8	6.8	6.6		7.6	7.3	7.0	6.3	6.3	6.1
sc-uS/CM	157	357	793	693		218	1331	437	489	714	1143
Temp-C	11.3	12.7	12.8	14.6		14.0	9.4	11.5	13.7	11.3	11.7
TDS	113	246	574	493	253	132	946	311	347	507	812
Acidity*	0	0		6							
Alkalinity*	27	8		104		41					
Hardness*	63	140	265	316	89	67					
Cl	1	8	19	7	13	13					
K	1	9	22	3							
Ca	33	64	114	155	152	19					
Mg	6	11	19	20	22	5					
Na	3	11	49	18							
P	0	0	0	0		0					
SO4	16	77	262	234	*87*	32					
NO3-N	7	7	6	2	3	1					
Ag	0.000	0.000	0.000	0.000							
Al	0.000	0.000	0.000	0.000		0.200					
As	0.000	0.000	0.000	0.000	0.000						
Ba	0.000	0.000	0.000	0.110	0.071						
Be	0.000	0.000	0.000	0.000							
Cd	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.016	0.000	0.008	0.008
Co	0.000	0.000	0.000	0.000							
Cr	0.000	0.000	0.000	0.000							
Cu	0.017	0.000	0.006	0.000	0.030	0.010	0.007	0.005	0.005	0.004	0.005
Fe	0.000	0.000	0.007	0.074	0.030	0.095					
Hg	0.000	0.000	0.000	0.001		0.000					
Mn	0.000	0.000	0.000	0.094		0.074	0.019	0.038	0.006	0.487	0.704
Ni	0.000	0.000	0.004	0.000	0.005	0.050					
Pb	0.000	0.000	0.000	0.000	0.000	0.001	0.005	0.002	0.002	0.002	0.002
Sb	0.000	0.000	0.000	0.000							
Se	0.000	0.000	0.005	0.002	0.000		0.000	0.002	0.007	0.012	0.025
Th	0.000	0.000	0.000	0.001							
V	0.000	0.000	0.000	0.000							
Zn	0.007	0.000	1.185	0.405	0.398	0.476	0.338	1.480	0.445	6.500	1.363
PCE-ug/L	0.0	0.0	2.1	0.0							

Notes: All values are totals, and are reported in mg/L unless noted.

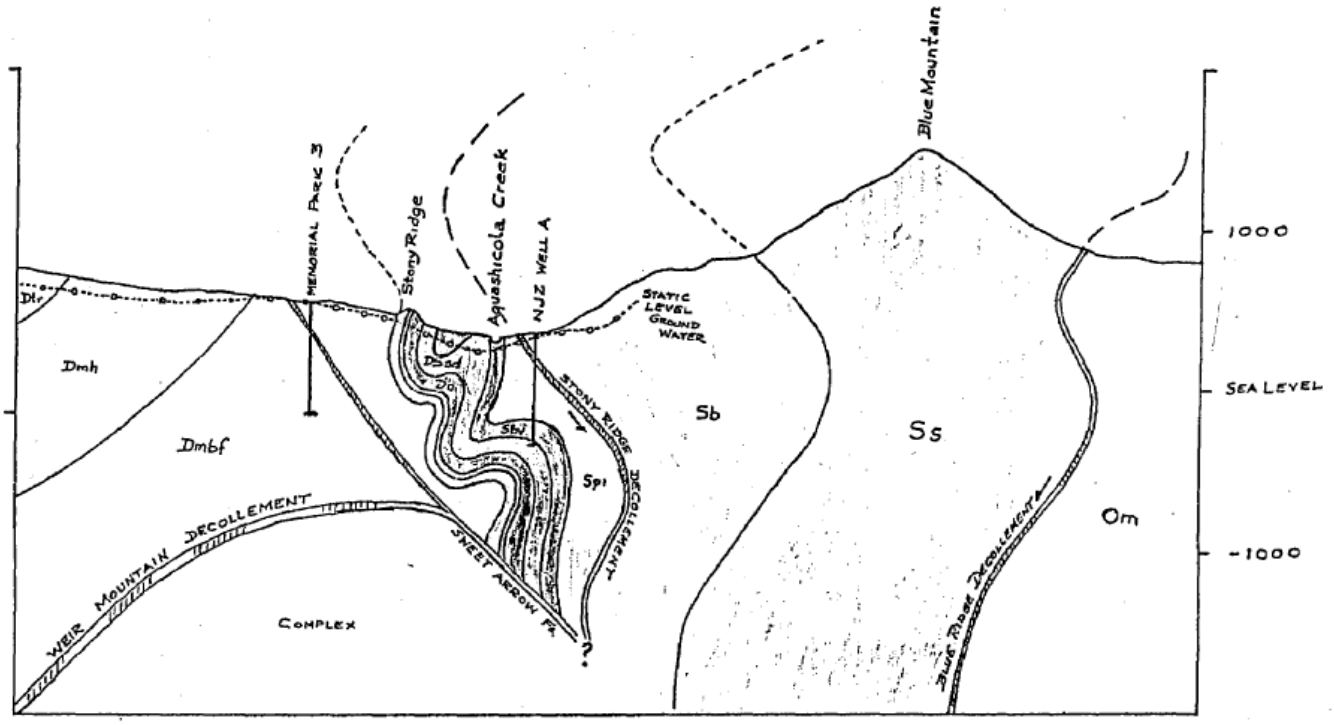
Values are averages for the year(s) shown, with non-detect values set at zero

Asterisk (*) inidicates values are reported in mg/L CaCO3

*TDS values in italiscs are computed from SC: TDS ~ 0.7103*SC*

SO4 values in italics computed from 55%:20%:15%:10% mixture of the four supply wells

Figure 1 - Geological Section Looking East



Dmh	Mahantango Fm	Massive-non bedded silty shale
Dmbf	Marcellus-Buttermilk Falls Fm	Marcellus - fissile clay shale
		Buttermilk Falls - argillaceous cherty limestone
Dp	Palmerton Fm	Coarse-grained, massive, sandstone, non porous
Dse	Esopus Fm	Well bedded fine grained siltstone
Do	Oriskany Fm	Quartz sandstone & pebble conglomerate
DSsd	Stormville & Decker formations	Sandstone & fossiliferous limestone
Db	Bossardville Fm	Thin bedded limestone
Spi	Poxono Island Fm	Laminated Dolomite and Shale
Sb	Bloomsburg Fm	Thin laminated red shale and siltstone

Source: A Geologic Study to Determine Potential New Well Locations, Palmer Water Company, Palmerton, Carbon County, Pennsylvania,

Figure 2 - Well Locations - Palmerton East Plant

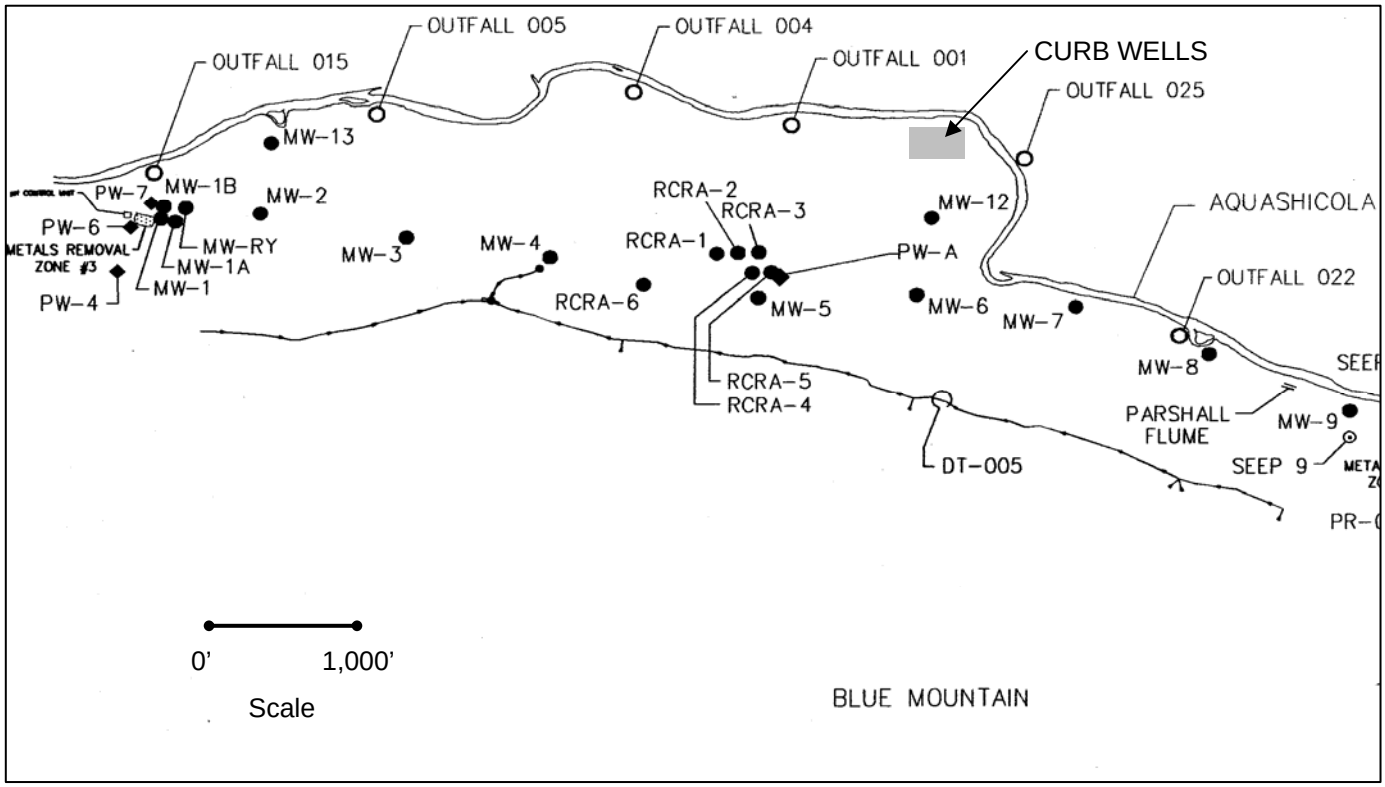


Figure 3 - Deep Wells - Zinc Concentration History

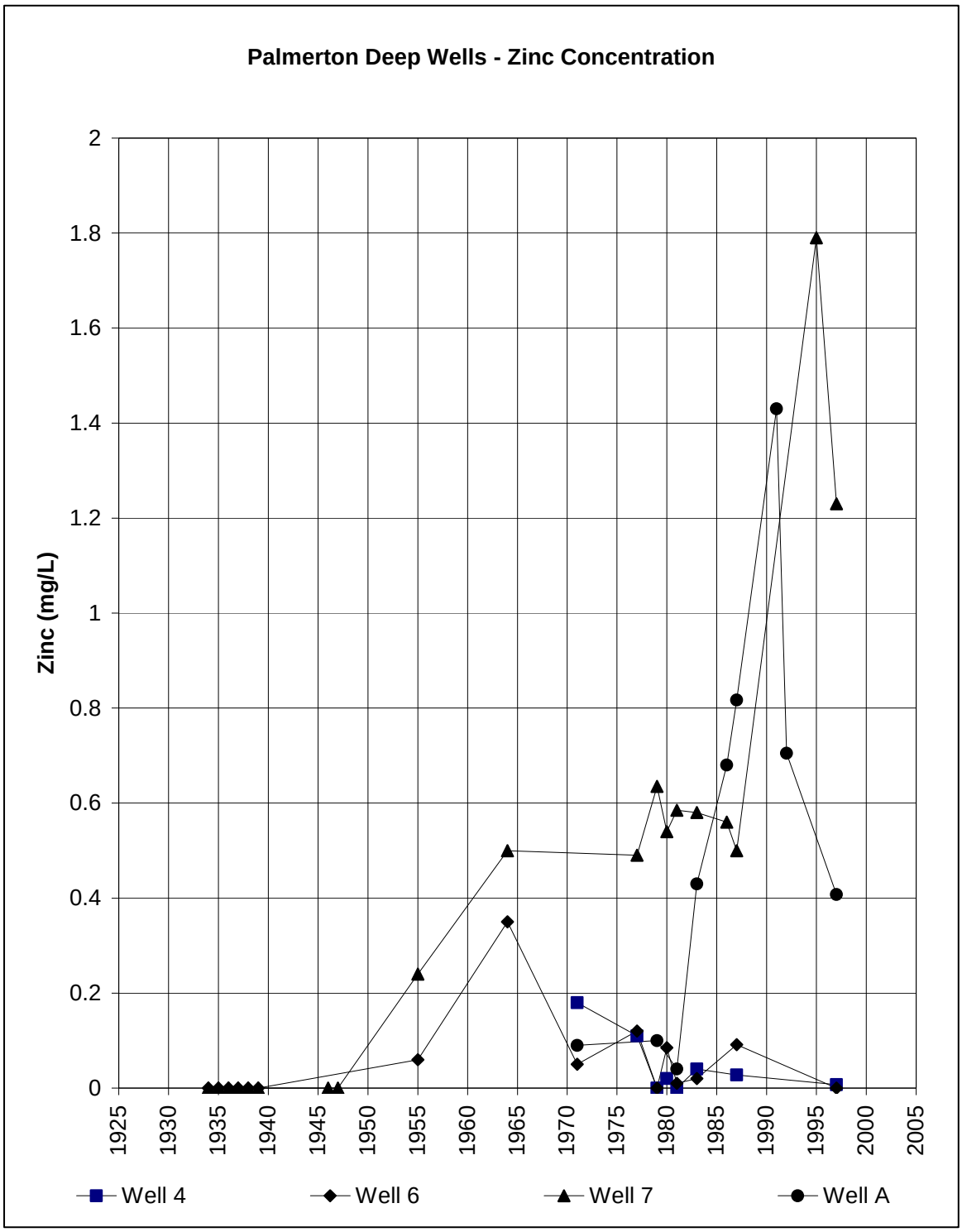


Figure 4 - Deep Well Sulfate History

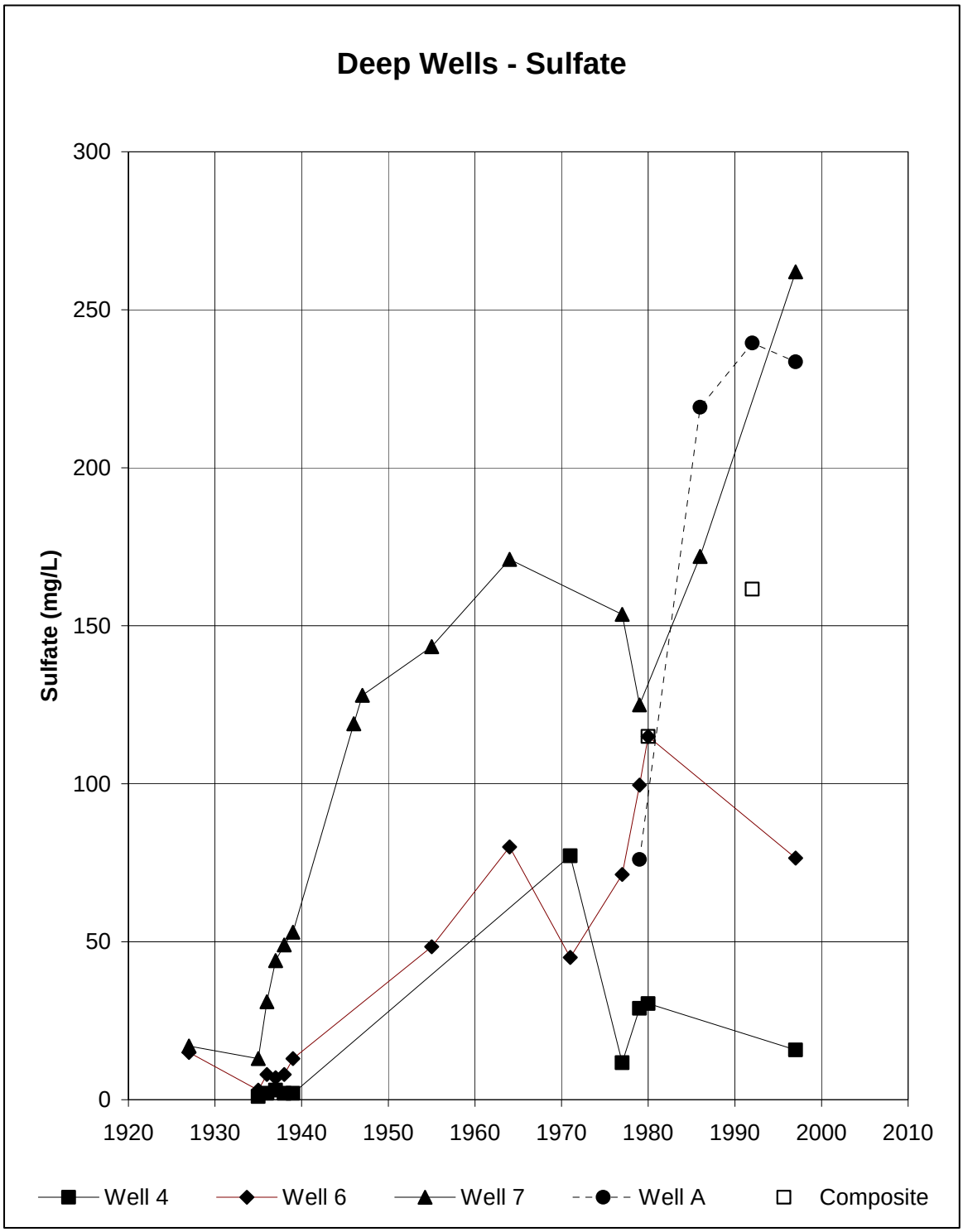
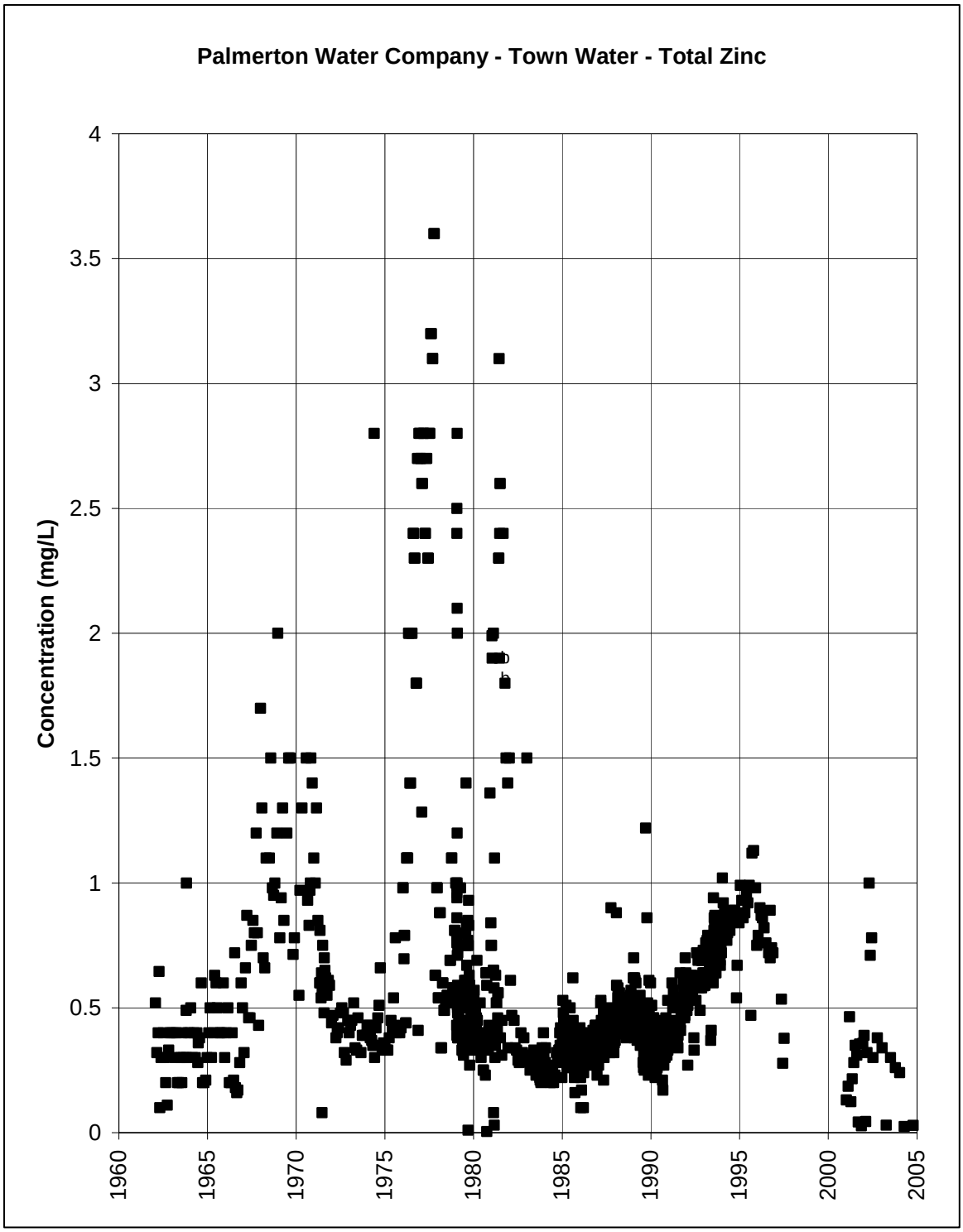


Figure 5 - Palmerton Water - Zinc Concentration History



Note: Six readings from the ZCA Laboratory in 1992 between 13 and 69 mg/L not plotted

Figure 6 - Monitor Wells - Zinc Concentration History

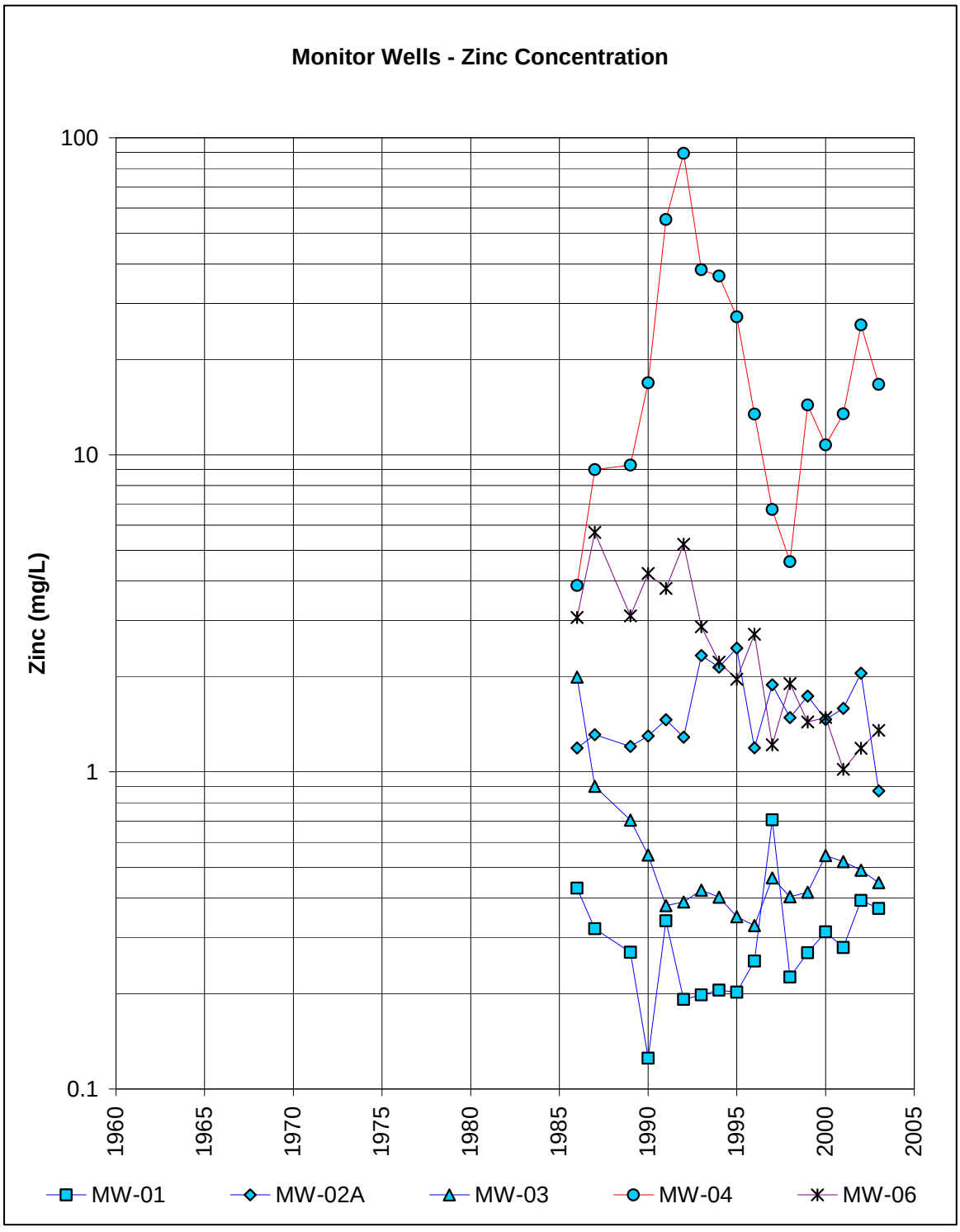


Figure 7 - Aquashicola Creek - Zinc Concentration History

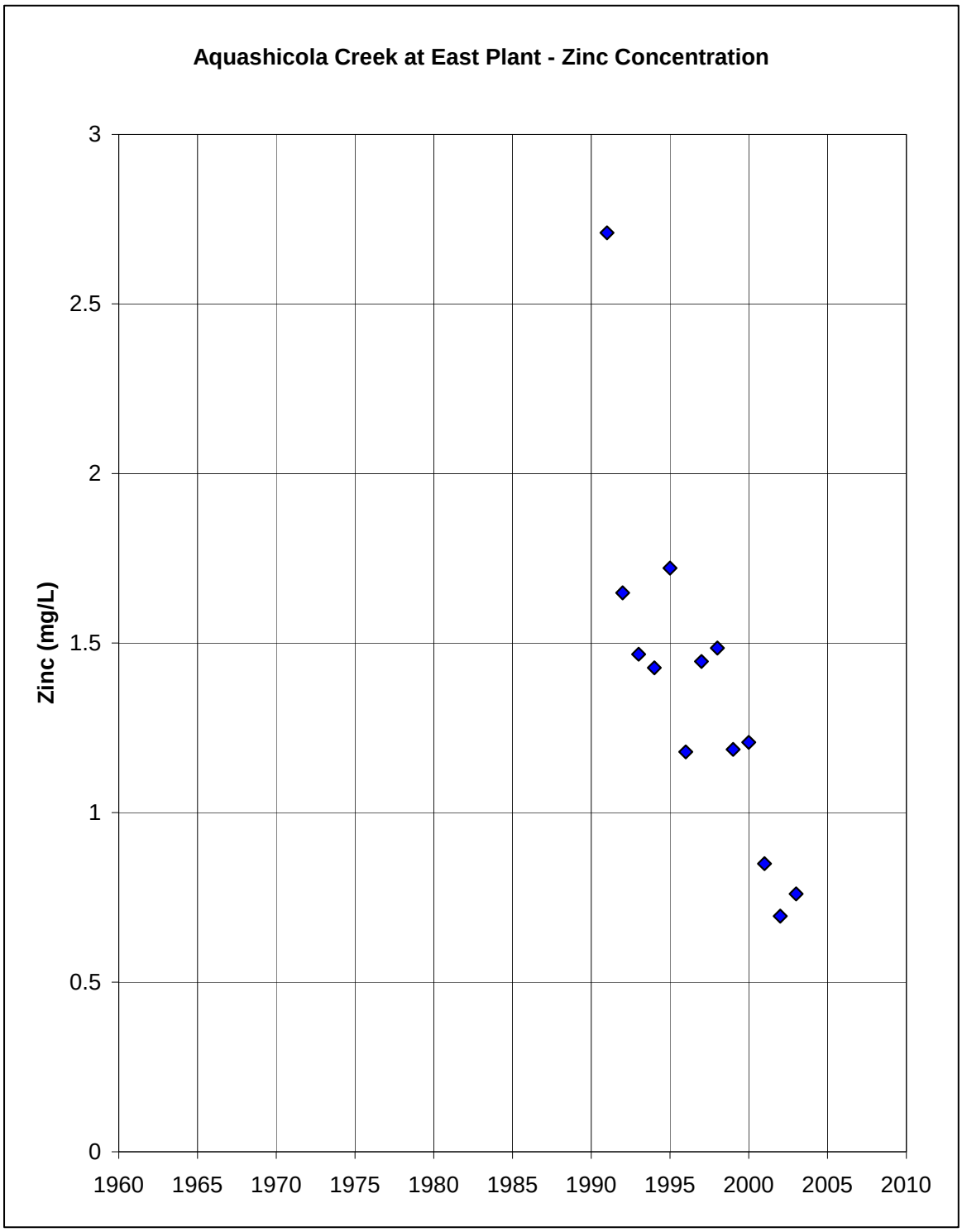


Figure 8 - Deep Wells - PCE History